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EXTENDING THE SEMIOTICS OF EMBODIED INTERACTION TO BLENDED SPACES

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Abstract: *In this paper, we develop a new way of understanding interactions in blended spaces. We do this by developing ideas about embodied semiotics and then apply these ideas to the analysis of interaction in mixed-reality blended spaces (where the physical world and digital world are blended deliberately to provide new forms of interaction). We discuss how blended spaces provide a new medium within which people have experiences. The semiotic analysis reveals how blended spaces are constructed across the physical and the digital, highlighting the ontology, topology, volatility, and agency present within them. It shows how people move between the physical and digital spaces through the objects and places that anchor them together. Our approach reveals more about the way bodily and higher cognitive functions are brought into play within a holistic interactive experience in which people move physically and conceptually through the layers of experience that make up the interaction.*

Keywords: *embodiment, cognitive semantics, semiotics, blended space.*

INTRODUCTION

The idea of embodiment is important to a wide range of pragmatic and philosophical investigations and discussions. It is central to experiential views of being, phenomenology, and cognitive science. Rohrer (2007) identified 12 uses of the term *cognition*, from the highly abstract to the detailed level of neuroscience. Embodiment is central to Lakoff and Johnson's (1981, 1999) views on cognition and to Fauconnier and Turner's (2002) theory of blending, or conceptual integration. This rich vein of philosophy goes all the way back to the earliest formulations of cognition and the importance of recognizing that humans think the way they do because they have bodies.

Towards the end of his chapter, Rohrer (2007) quoted the American pragmatist philosopher, William James, writing in the early 1900s: "We think; and as we think we feel our bodily selves as the seat of the thinking" (p. 373). This philosophy, based in experience, continues to be influential today and resonates with phenomenological views of experience. These deny the

validity of an analysis of whole experiences in terms of their parts and recognize instead that the whole of some phenomenon needs to be understood if the essence of that phenomenon is to be uncovered. McCarthy and Wright (2004) pursued this holistic view of technology as experience, drawing on the work of another pragmatist, John Dewey. They also emphasized the “felt sense” of experience. Both James (1907) and Dewey (1935) built on the work of the person credited by James as the founder of the pragmatist movement: Charles Sanders Peirce. Peirce (1931–1935, 1958) developed a view of how people understand and act in the world expressed in terms of semiotics, a view that is still very relevant today.

In this paper, we develop a semiotics of embodiment in order to bring out the multilayered nature of experience. We apply these ideas to the analysis of interaction in mixed-reality blended spaces (Benyon, 2012, 2014). These are spaces where the physical world and the digital world are blended deliberately to provide new forms of interaction. The contribution of this paper is an improved understanding of how blended spaces are experienced and how people move through these spaces, making meanings as they do.

Milgram and Kishino (1994) characterized a spectrum of reality, from virtual reality at one end to physical reality at the other end, with mixed reality in between. Touch and gestural interfaces are examples of augmented virtuality because the digital space of software is augmented with the physical characteristics of gesture. Augmented reality can be achieved through the overlays of graphics and text onto real-world scenes. Various combinations of the physical and the digital provide a whole new set of interactions. Our interest is to explore people making meaning in the blended mixed-reality spaces of next-generation interaction.

Steve Benford and his colleagues have been researching mixed reality for some years (e.g., Benford, Greenhalgh, Reynard, & Kolva, 1998) and more recently discussed hybrid spaces and how people move through trajectories of hybrid experiences (Benford, Giannachi, Kolva, & Rodden, 2009). Wagner et al. (2009) also discussed a number of mixed-reality experiences and how people move through different spaces and engage in rich, new social phenomena.

The idea of a blended space aims to formalize the craft that has gone into building these mixed-reality experiences by focusing on the correspondences between the physical and the digital spaces. A blended space takes advantage of the physical and social structures in the physical and digital spaces, bringing them together to create multilayered experiences that have their own emergent structure (Benyon, 2012).

In this paper, then, we explore how people make meanings in blended spaces. We do this first by developing the ideas of blended spaces, spaces where the physical space has been commingled deliberately with a digital space to provide new interactive experiences. We then turn our attention to semiotics, the study of how people make use of signs (O’Neill, 2008). O’Neill developed a semiotics of embodied interaction that placed semiosis on a continuum from pure experience at one end to abstract, reflective knowledge at the other end. This allowed him to look at other philosophical stances such as Heidegger’s (1962) notions of present-at-hand and ready-to-hand alongside Peirce’s (1931–1935, 1958) and Eco’s (1976) semiotics. He applied this analysis to some interactive products. In this paper, we extend this analysis to take a semiotic look at some examples of blended spaces. In addition, we develop a notation for mapping out the key semiotic relationships that we believe are central to the sense of presence in two blended spaces. Benyon (2012, 2014) argued that people have an extended sense of presence in a blended space because the blended space provides a medium that embraces both the physical and digital space. The semiotic analysis enables us to describe and map this medium.

Semiotics has been applied to linguistics (Peirce, 1931–1935, 1958), film (Metz, 1974), product design (Vihma, 1995), computers (Andersen, 1990), interface design (de Souza, 2004), architecture (Gottdiener & Lagopolous, 1986), and a whole host of other areas. Although semiotics usually is seen as a theory of communication and of how signs are encoded, transferred through a medium, and decoded, we develop a semiotics of interaction, promoting interaction as a fundamental semiotic concept. Thus in the fourth part of this paper, we present this view of semiotics, building on the ideas of embodied cognition and the semiotic theories of C. S. Peirce (1931–1935, 1958) and Umberto Eco (1976), resulting in a further developed semiotics of embodied interaction. In preparation, we present a discussion of mediation. Bringing these two developments together allows us to apply the ideas of semiotics of embodied interaction to some examples of blended spaces. Hence we need to begin with a discussion of blended spaces.

BLENDED SPACES

In their book, *The Way We Think*, Fauconnier and Turner (2002) introduced their ideas on a creative process that they called “conceptual integration,” or blending. They argued that cognition could be seen in terms of mental spaces, or domains. Cognition involves the projection of concepts from domains and their integration into new domains. With blending theory, Fauconnier and Turner (2002) developed and extended the ideas of Lakoff and Johnson (1981, 1999) regarding the importance of metaphor to thought. Where metaphor is seen as a mapping between two domains, Fauconnier and Turner saw blending in terms of four domains. They explained the simple but powerful process as follows (see Figure 1). Two input spaces (or domains) have something in common with a more generic space. Blending is an operation that, when applied to these two input mental spaces, results in a new, blended space. The blend receives a partial structure from both input spaces but has an emergent structure of its own.

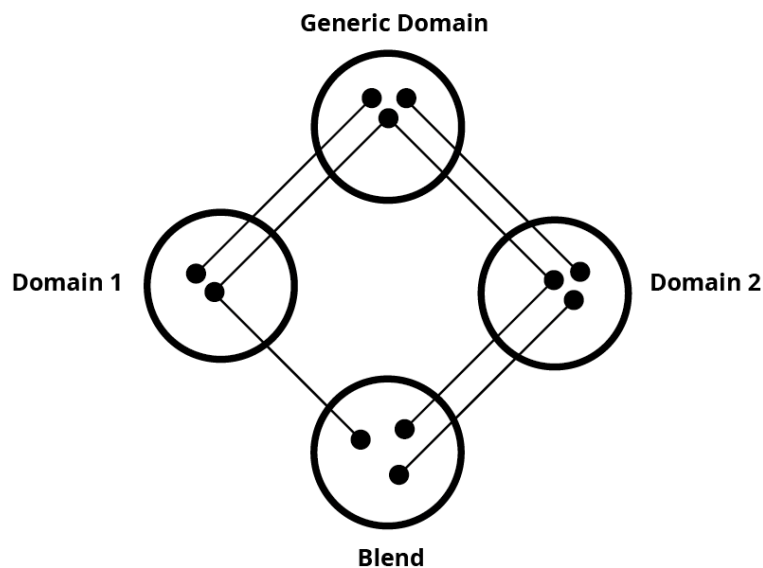


Figure 1. Concept of a blend.

In linguistics, blending theory is used to understand various constructs such as counterfactual statements and metaphors and to understand how different concepts arise (Fauconnier, 1997). For example, blending theory can be used to understand the difference between *houseboat* and *boathouse* by looking at the different ways in which the concepts of house and boat can be combined. There is now extensive work on blending theory applied to all manner of subjects that offer different insights into the way people think. To learn more, Mark Turner's Web site¹ is a good starting place.

The main principles of blending are that (a) the projections from the input spaces create new relationships in the blend that did not exist in the original inputs and (b) our background knowledge in the form of cognitive and cultural models allows the composite structure to be experienced in a new way. The blend has its own emergent logic, and this can be elaborated to produce new ideas and insights. This blended space may then go on to be blended with other mental spaces (Fauconnier, 1997, p. 149–150).

Fauconnier and Turner (2002) discussed different types of blends and provided guidance on what makes a good blend. Four types of blends are identified based on the way in which concepts from the input spaces are projected into the blended space, from simple one-to-one mappings to more complex “double scope” blends that creatively merge concepts from the input domains to produce a new concept. Fauconnier and Turner saw the process of blending as consisting of three main processes: (a) composition, the process of understanding the structure of the domains; (b) completion, the process of bringing relevant background knowledge to the process; and (c) elaboration, the process of making inferences and gaining insight based on these relationships. They proposed six guiding principles to support the development of blends. The first three, integration, web, and unpacking, concern getting a blend that is coherent and in a form that people can understand where the blend has come from. The fourth, topology, concerns the correspondences between the input spaces. The fifth, “good reason,” captures the generic design principle that things should only be in the blend if there is a good reason for them to be included, and the sixth, metonymic tightening, concerns achieving a blend that does not have superfluous items in it (Fauconnier & Turner, 2002, p. 47–48).

Imaz and Benyon (2007) have applied the ideas of conceptual blending to analyze developments in human–computer interaction (HCI) and software engineering. They analyzed a number of well-known examples of user interfaces, including the trash can icon and the device eject function in the Macintosh computer's operating system; they also examined critical HCI concepts, such as scenarios and use cases. One example they considered is the concept of a window in a computer operating system. This is a blend of one mental space, the concept of a window in a house, and another mental space, the concept of collecting some computer operations together. The generic space is the idea of being able to see a part of a large object, a window on the world if you like. The process of bringing these spaces together results in a new concept of *window* that now includes things such as a scroll bar, a minimize button, and so on, that one would not associate with a window in a house. The blended space of a computer window has inherited some shared characteristics from the generic space of “looking onto something” but now has its own characteristics and emergent properties. This is illustrated in Figure 2.

Imaz and Benyon (2007) argued that, in interaction design, designers need to reflect on and think hard about the concepts that they are using and how these concepts affect their designs. They emphasized the physical grounding of thought by arguing that designers need to find

solutions to problems that are at a human scale. Drawing upon the principles of blends suggested by Fauconnier and Turner (2002), they presented a number of HCI design principles.

When creating a new interface object or new interactive product, designers often will create a blend from existing designs. Designers should aim to preserve an appropriate topology for the blend, allowing people to unpack the blend so that they can understand where the new conceptual space has come from. There are principles for compressing the input spaces into the blend, aiming for a complete structure that can be understood as a whole (the integration principle) and for keeping the blend relevant and at a human scale. This principle aims to foreground the person in a technology–person relationship by focusing the design on human abilities and human concerns rather than on technological issues.

Imaz and Benyon (2007) went on to present an abstract design method that showed how conceptual blending can be used during the analysis phase of systems development to understand the issues of a particular situation and how it can be used during the design stage to produce and critique design solutions. For example, they discussed the existence of the trash can on the Windows desktop. Here the designers have chosen not to enforce the topology principle (which would suggest, in this case, that because trash cans normally go underneath a desk, the trash can should not be on the desktop). Instead the designers have promoted the integration principle, keeping the main functions of the interface together in a desktop metaphor.

Conceptual blending has been used to inform design in a number of other settings. In an ambient assisted living scenario (Hoshi & Waterworth, 2011), the space for information concerning the receipt of e-mail messages was blended with a lighting display to create a novel space of interaction in which the background lighting changed to indicate changes in e-mail status. Wang (2013) provided a fascinating discussion about applying blending theory to the design of a table lamp, and Markussen (2009) discussed blends with respect to the design of a blood-taking machine and the tension between the emotional response and expectations of use.

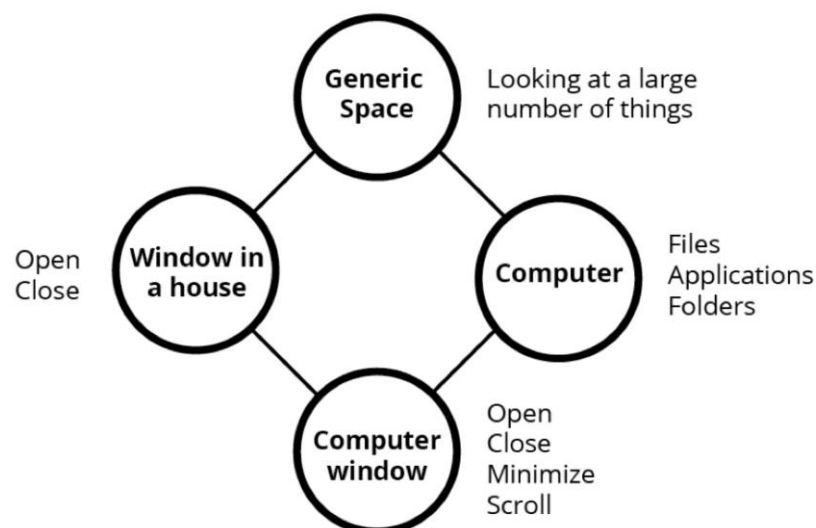


Figure 2. Blend for a computer window.

The danger in presenting blending theory in such a short section is that it can seem trivial, when in fact it is a very powerful idea. Underlying blending theory are ideas about embodied cognition that go back to the roots of how human cognition starts with the bodily experiences that humans have as babies growing up in a three-dimensional world. Lakoff and Johnson (1999) developed this “philosophy of the flesh” from a conceptual perspective, and Rohrer (2005) developed related ideas from a cognitive science and neurological perspective. People think the way they do because of their inherent physical and perceptual schemata that are blended to produce new concepts that in their turn are blended to form new concepts. Understanding this background helps designers to create experiences at a human scale.

Another contribution to blending theory is the concept of a “material anchor” (Hutchins, 2005). Hutchins referred to the idea of an association of a conceptual structure with a material structure as “a general and ancient cognitive phenomenon” (p. 1558). He gave the example of a queue of people as a blend between the abstract idea of a “trajector” (something that has a trajectory) and a line of people. One would not consider a football team lining up at the start of a game to be a queue, but it is a line of people. It is when the line of people is blended with the idea of a trajector that the queue concept is formed along with the various features of queues, such as one’s position in the queue and the first-in, first-out logic of a queue. Hutchins made the significant observation that it is the physical experience of the line that is one of the input spaces to the blend, not the concept of a physical line. In this blend, one input space is embodied in the physical world—it is a material anchor—and the other is a conceptual idea of a trajector. Hutchins argued that having a material anchor for a blend provides a more stable conceptual structure that supports more complex reasoning.

Fauconnier (1997) pointed to the more general applicability of blending. “Conceptual blending is not specifically linked to language use. It operates in many areas of cognition, including design and action” (p. 171). Imaz and Benyon (2007), Hoshi and Waterworth (2011), and Wang (2013) explicitly transferred the ideas of mental spaces to the design of artifacts. The assumption here is that people will develop mental representations of designed objects, so if designers consider how people may react to new experiences as part of the design process, a better, more understandable design will result. Mark Turner, with his students and colleagues, also has developed blending theory into many areas beyond linguistics, including music, mathematics, the social sciences, and pedagogy. Most recently he has applied ideas of blending to the origin of creativity and to when humans became “cognitively modern” (Turner, 2014). In another contribution to the generality of blending theory, Thomas Markussen argued that “blending theory is a semiotic theory of how we form representations and categories based on the notion of embodied cognition” (Markussen, 2009, p. 33).

Benyon (2012, 2014) takes the ideas of blending theory and applies them to the design of mixed-reality spaces. He argues that, for the purpose of designing mixed-reality spaces, it is useful for designers to consider digital and physical spaces in terms of four characteristics: ontology, topology, volatility, and agency. The theory is that, in a blended space, people will develop a mental space of the digital domain and a mental space of the physical domain and experience these together, partially projected into the blended space. It makes sense for designers of blended spaces to consider the correspondences between the digital and physical domains so that the blended space is designed in an effective, harmonious way, at a human scale. Bringing blending theory together with the idea of physical and digital spaces leads to the position illustrated in Figure 3.

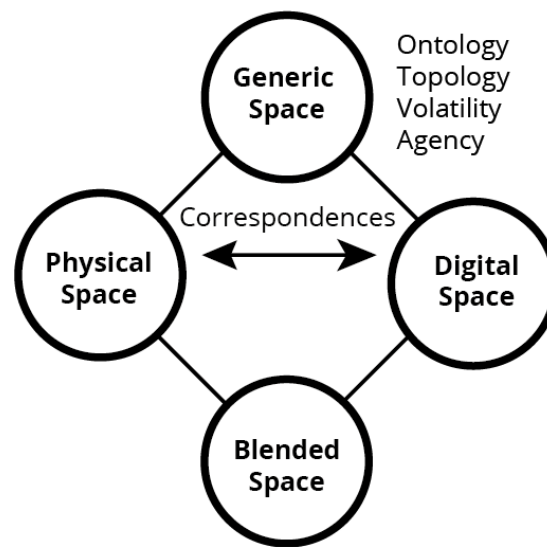


Figure 3. Conceptual blending in mixed-reality spaces.

The ontology of the spaces concerns the objects in the spaces. The topology of the spaces concerns how those objects are related to one another. The dynamics or volatility of the spaces concerns how elements in the spaces change over time. The agency in the spaces concerns the people in the spaces, the artificial agents, and the opportunities for action within the spaces. By understanding these characteristics and looking at the correspondences between the physical and the digital spaces, designers will produce new blended spaces that have emergent properties. In these spaces, people will not be in a physical space with some digital content bolted on: Rather, people will be present in a blended space and this will give rise to new experiences and new ways of engaging with the world.

The conceptualization of blended spaces, illustrated in Figure 3, relies on a generic way of talking about spaces—ontology, topology, volatility, and agency. This is the generic space of spaces and places that is projected onto both the physical and the digital spaces. The correspondences between the physical and the digital are exploited in the design of the blended space. The job of the designer is to bring the spaces together in a natural, intuitive way to create a good user experience and to give people the sense of being present in a blended space. The designer should design the blended space according to the principles of designing with blends, such as drawing out the correspondences between the topology of the physical and digital spaces, using the integration principle to deliver a whole experience, and designing at a human scale.

Another important consideration in the design of blended spaces is that the physical and the digital spaces rarely coexist in their entirety. There are anchors, or touch points, where the physical is linked to the digital, but there are many places where the physical and the digital remain separate. Quick response codes or GPS are examples of anchor technologies that bring the physical and the digital together. For example, in the context of blended spaces for digital tourism, one may observe a person walking through a physical space, accessing digital content on an iPad, and then continuing his or her physical movement. Thus, in blended spaces,

people move between the physical, the digital, and the blended spaces. This movement through and between spaces is an important part of the blended space concept and leads on to issues of navigation in physical, digital, and blended spaces. It appeared in Benford and colleagues' work on spectator interfaces as the idea of a hybrid trajectory (Benford et al., 2009).

A blended space encompasses a conceptual space of understanding and making meaning, and this is where the principles of designing with blends are so important. As we explain in the next section, people make meanings by interacting with the different signs and symbols and structures that constitute their environment. In blended spaces, people need to be aware of both the physical and the digital spaces, what they contain, and how they are linked together. People need to understand the opportunities afforded by the blended space and to be able to unpack the blend to see how and why the spaces are blended in a particular way. People need to be aware of the structure of the physical and the digital, so that there is a harmony brought about by the correspondences between the objects in the spaces. The overall aim of blended spaces is to design for a great user experience at a human scale.

MEDIATION

Blended spaces provide a new medium within which people will act, feel, and make meanings. Our view of how they do that is based on the embodied semiotics that we explore in the next section. However, before we do that, it is important to understand the significance of mediation to cognition and communication. A simplistic view of this is the conduit metaphor of communication. This states that meaning is transmitted along a channel (in the form of signs) from a source to a destination. However others, notably Michael Reddy (1993), argue that the conduit metaphor of meaning—the view of meanings being transferred—is fundamentally mistaken. Meanings arise from people interacting with objects and signs in a medium. When Francisco Varela was asked about the mind, he apparently retorted: “The mind is not in the head” (Varela, Thompson, & Rosch, 1991, p. 63). This raises a question: Where is it then? But this question itself is a consequence of thinking about concepts as things. If people believe that concepts are things, it is evident that if the mind is not in the head, it must be somewhere else. However, if people think about the mind as interaction, they no longer try to look for it in a particular place.

One is reminded of “The Grand Academy of Lagado” in *Gulliver's Travels* (Swift, 1726), where scientists conduct experiments to remove words altogether, turning conversation into the practice of carrying around a large collection of objects to be pointed at in order to communicate. This is of course absurd, but it illustrates an important point about mediation and the mind. First, it illustrates that some “thing” must exist in the world in order to mediate concepts between people. Whether it is words, objects, or interfaces is not particularly important. What is important is that the stuff of the world itself, including one's body, has the capacity to be formed and reformed by physical manipulation in order to represent ideas. In doing so, the stuff of the world holds concepts for people, relieving them of the need to keep these concepts in their heads. This allows people to perceive, recognize, and reuse the concepts as and when needed. In short, the stuff of the world is able to act as a medium through which people can communicate because (a) it is malleable and responsive to physical

transformation and (b) people too are physical beings that can act on it, taking advantage of the physical laws of cause and effect.

The essential point here is that the physical stuff of the world that holds concepts for people essentially allows them to “off-load” cognition into their environment. The realization that people can intentionally mark the world around them allows them to give form to their thoughts and experiences. In giving form to ideas, people no longer have to hold them in their heads. The world can hold the ideas for them. The “invariant repertoire of behavior” (Gibson, 1979) that a medium affords people can give an idea a level of stability that the mind cannot.

The upshot of this is that people live in a world that is not only populated by physical representations of ideas but also deeply inscribed by generations of ideas that are layered one on top of the other. Heidegger (1962) described this situation as “thrownness,” where people find themselves already living in a “naturalized” environment where the minds of previous generations are already available to them as they are inscribed on the world in the form of books, poems, and paintings, as well as houses, rooms, cars, and computers. In such a way, the media surrounding people, which are representations of other people’s ideas, become the norm, the everyday and the mundane backdrop to their own lives. Marshal McLuhan (1964) famously described the mediation of ideas that surrounds people as being like water is to fish. Fish are only “aware” that they live in water when they are taken out of it. Like fish, people are essentially unaware of their mediating surroundings, particularly the degree to which the surroundings contribute to their ability to think and communicate.

With the idea out in the world formed by a medium, people are more readily able to engage with it not only in an intellectual “present-at-hand” way, as Heidegger would describe it, but also in a “ready-to-hand” way. In a sense, what Heidegger (1962) described as the ready-to-hand way of being is such that the medium disappears allowing people to act through it to achieve something else. The idea of the “hammer” is a well-known example of the “extensions of man” (McLuhan, 1964) that Dourish (2001) and Heidegger (1962) used to illustrate these different modes of being, but it goes further than this. Essentially, the mediation of ideas by the stuff of the world not only allows people to get ideas out of their heads and into the world, it also allows them to engage with those ideas physically through their bodies. Hence people sleep on beds, people drive cars, people operate computers, and people inhabit blended spaces.

Interacting with media of all kinds then falls between these two modes of being. On the one hand, people perceive and encounter their media-rich environment directly and manipulate it and transform it through their ready-to-hand mode of being. On the other hand, they constantly are viewing, reading, and interpreting mediated information through the reflective mode of encountering it as present-at-hand. At the same time that people move between these two modes of being, they inscribe, interpret, transcribe, and transform their mediated environment. In a very clear sense, people are entwined physically and deeply with the media in their environment and, in another sense, they are making—and making sense of—the inscriptions that the media environment affords them.

In a semiotic theory of embodied interaction, it is therefore important to know how mediation is taking place in relation to the body. It is important to know what kinds of signs are being used in the system and how they represent reality when people come to use them. It is also important to know at what level of abstraction concepts have been embedded into their environments. For example, are people supposed to experience something viscerally, to interact bodily by pushing buttons or making gestures, or intellectually by bringing their cultural understanding to bear on

the situation? At times, it will be both; at other times, bodily interaction may be foregrounded over intellectual and vice versa. Always there will be a need for designers to think carefully about how to choreograph interaction, by placing the right signs in the right order at the right time to facilitate the flow of smooth coping.

THE SEMIOTICS OF EMBODIED INTERACTION

Semiotics concerns the use people make of signs. Traditionally in semiotics, researchers have studied linguistic signs, such as words, sentences, and texts but, increasingly, semiotics has been applied to a range of other subjects as well, such as product design, architecture, cinema, marketing, computing, and HCI. The wide range of applications of semiotics and the different ways in which it is used can be rather daunting. Philosophers trying to understand how meanings are created, communicated, and understood can use it. Cultural commentators discussing the significance of images, texts, or events use it. Politicians, advertisers, and others trying to persuade people to adopt a certain understanding towards some product or idea use it. Here, one of the authors redevelops ideas first presented in his book *Interactive Media: The Semiotics of Embodied Interaction* (O'Neill, 2008) in order to define the relationship between semiotics and embodiment in a way that is useful for thinking about blended spaces.

This redevelopment of embodied semiotics is focused around Jacob von Uexküll's notion of autopoietic perception–action loops (Deely, 2001). These loops are specific to the genetic and environmental niches of organisms, resulting in what are described as the *Umwelten*, or the self-centered worlds, that organisms inhabit. Importantly, it is the physical interaction, at an embodied level, between the organism and the environment that creates these worlds. O'Neill's (2008) "spectrum of embodied semiotics" also draws upon an understanding of phenomenology, ecological psychology, metaphor theory, conceptual blending, and the semiotics of Peirce (1931–1935, 1958) and Eco (1976). We redraw it conceptually and diagrammatically to expose the different levels of abstraction where signification takes place, intentionally unpacking the various stages and levels of semiosis for the purposes of explanation. In reality they probably are "squashed" together phenomenologically because of thrownness (Heidegger, 1962). These days, so many experiences of the world occur rapidly in tandem both directly and through mediation. This is because people are part of inherently semiotic, socially networked, and culturally technologized groups of beings (families, tribes, cities, regions, nations, etc.) and are not single isolated units alone in the wilderness. The reason for taking the time to differentiate the stages and levels of embodied semiotics is that it offers useful explanatory power to grapple with the ever-increasing semiotic existence.

Blended spaces are prime examples of the complex world in which people now live. This is a world where the physical and digital are intertwined tightly, providing the potential for a new sense of presence and having properties not possessed by either the physical or the digital spaces on their own. If people aim to design blended spaces that others can understand, use, and enjoy successfully, they need new ways to grapple with them.

The figures presented in this section are for illustration purposes and, as yet, do not constitute a formal notation. However, we do use them in the next section to try to express the semiotic systems of our examples.

Stage 1: Pure Experience

The first level of experience is the pure authentic experience of the undifferentiated continuum of sensation. Peirce (1931–1935, 1958) called this “firstness” in his ontology, and Eco (1976) referred to it as the “purport,” or stuff of the world. Although normally it would be argued that this stage is presemiotic (or protosemiotic), it is important to understand that people are already existing embodied bundles of codes (genetic) that have been thrown into an already existing coded world (cultural), a world that shapes and forms people as they shape and form it. At the center of this is people’s autopoietic perception–action loop, tightly and structurally coupled to the world (Figure 4). It is this autopoietic interaction that drives evolution, and it essentially is based on sensory experience. Eco’s idea of “primary iconism” begins here in as much as “the elementary condition of semiosis would be a physical state whereby one structure is willing to interact with another” (Eco, 1999, p. 107).

Stage 2.1: Tight Coupling

This level is the home of Gibson’s (1979) ecological theory of direct perception, where the coupling of an organism to an environment results in embodied, nonrepresentational cognition, affordances, and a species-specific *Umwelt*, or environment. As per Deely (2001), it is von Uexküll’s protosemiotic world of cause and effect that links an organism to its particular ecological niche. In von Uexküll’s terms, an autopoietic organism that is driven by an implacable need for survival and reproduction has, by necessity, a tendency to take habits that successfully maintain its existence. In our view, these habits result in tacit “embodied schemas” that are directly coupled to the world and that emerge in Stage 2.2. Here though, Eco’s (1976) concept of “primary iconism” moves towards Peirce’s (1931–1935, 1958) “secondness” as structures interact in a protosemiotic way with a predisposition to correspond. Secondness is the state of interaction where an effect has a direct correspondence to its cause. For example, when an original is impressed into sand to make a mold from which to make copies, the mold exhibits secondness whereas the copies would correspond to Peirce’s (1931–1935, 1958) state of “thirdness,” as they would stand in for the original. One should note that, for Eco (1976), primary iconism is an aspect of firstness that leads very quickly to secondness and only really can be traced back to firstness once the state of secondness has been realized. “Natural primary iconism would be the quality proper to impressions that still have not found (necessarily) their impresser but that are ready to ‘recognize it’” (Eco, 1999, p. 110).

Stage 2.2: Primary Embodied Schemas

This level can be described, in humans, as the development of bodily schemas or semiotic primitives that are manifest in the motor circuits that develop as they interact with the world



Figure 4. An autopoietic functional cycle (perception–action loop), adapted from von Uexküll (in Deely, 2001).

around them (Allot, 1992, 1994). Thus, the primary way of understanding the world emerges as an embodied understanding of the world in terms of embodied schemas (Figure 5). These basic schemas, such as up–down, in–out, along-a-path, and so on, form the basis of thought as has been explored by a number of philosophers and linguists, notably Lakoff and Johnson (1981, 1999). They represent basic categories of experience and guarantee a relationship to reality because they are derived from the physical relationship that people have with their environment and are precognitive. These are the basic building blocks of cognition and are what makes inference and semiosis possible in the first instance, as the primary interpretants of the external world. For example, it is very easy to see how a perception–action loop coupled to the environment could result in an embodied schema about being “inside” or “outside” something. This is known as the “container schema” and is derived by human actions of putting things into or taking things out of other things, including people themselves (e.g., people’s entire lives are about moving from one container to another in the form of architecture). There are many of these schemas that result from embodied interaction with the world at this level.

Stage 3.1: Internalization

This level concerns habits that are formed through engaging with the world through imitation and that become actively practiced as a way to recreate previous events (Dreyfus, 1998, 2004). This practice also is internalized, and auto-stimulation represents direct perceptual experience. People begin to remember things: physically, emotionally, and cognitively (they go over them in their heads/bodies, reenacting them internally). The recognition of a sensation and the comparison of internalized processes with new experience result in new knowledge that is abstracted about the world. Embodied schemas are brought into play as a way of recognizing and differentiating between these experiences. The first blends appear (Figure 6): a mixture of direct experience and practiced/remembered experience. In other words, what Eco (1999) described as “cognitive types” are formed from direct experience, interpreted through embodied schemas. Cognitive types (CTs) could be described as conceptual schemas that contain information about the look, feel, touch, or smell of an object. Eco did not go as far as to define them or to determine whether they exist in the mind or not; he simply posited that they exist (Eco, 1999, p. 130). Importantly, at this stage, the first step is taken to cross the semiotic threshold into Peircean thirdness (Peirce, 1931–1935, 1958), as signification begins as part of the internal processes of visualization and thinking.

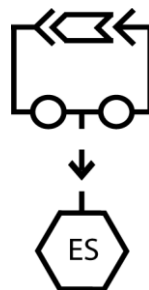


Figure 5. Primary embodied schemas (ES), the direct result of embodied interaction with the world.

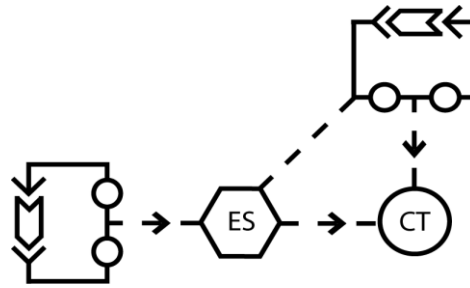


Figure 6. Embodied schemas (ES) help a person interpret new experiences and form cognitive types (CTs).

Stage 3.2: Semiosis and Imagination

At the next level, internalized CTs interpret direct experience through comparison and differentiation. They also interpret other internalized CTs (Figure 7). Metaphorical mapping and conceptual blending take place, and new CTs are formed that are not directly related to external experience (Fauconnier & Turner, 2002). The imagination is born, and unlimited semiosis is set free (Peirce, 1931–1935, 1958).

Stage 3.3: Expression

Activities continue to be practiced as a way of recreating events for perception. CTs are expressed externally as something that Eco called “nuclear content” (NC), which in common parlance is simply content. Here an abridged version of a CT is formed in a medium, for example, the expression of ideas through mark making, art, or language (Eco, 1999, p. 136–141). The environment takes on the role of mediating ideas and starts to contain representations of real or invented phenomena (Figure 8). The cognitive load of thinking is offloaded partially onto the world; cognition becomes distributed and embedded in the world. People enter the organizational zone of the creative process and manipulate the stuff of their environment through understanding the signs attached to it and by constructing further signs to place in the environment for others to find.

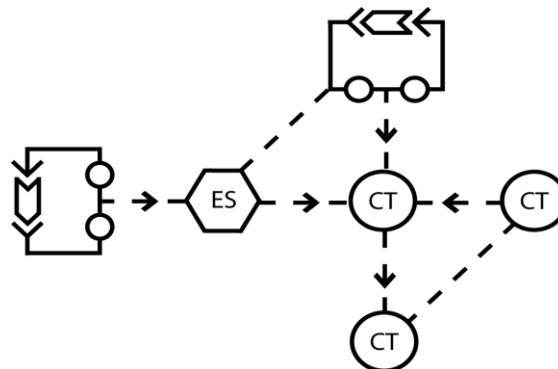


Figure 7. Cognitive types (CTs) are brought into relation to one another, and unlimited semiosis is set free.

Note. ES = embodied schema.



Figure 8. The expression of cognitive types (CTs) is impressed into the medium of the world in condensed form as nuclear content (NC).

Stage 3.4: The Mediating Environment

At this level, representations are embedded fully in the environment. Interaction with NC is communication, and it results in further CTs. However, CTs derived from NCs are not qualitatively the same as those derived from direct perceptual experience. For example, the CT of a real horse is not the same as the CT of a drawing of a horse. Experience gained through NC only results in what we call *diminished CT* (CT-; Figure 9). One does not have to experience something to know something about it or be able to communicate that knowledge to someone else. For example, a person who has never been bitten by a snake does not know what that would be like, but most likely does not want it to happen. He or she has not had the experience, but has learned about it from others through the NCs encountered in his or her life.

Thus his or her experience of snakes is diminished somewhat (with good reason). Although all semiosis takes place through the interpretation of representations of objects, it is important to remember that Peirce (1931–1935, 1958) stated that representations can be interpretants in their

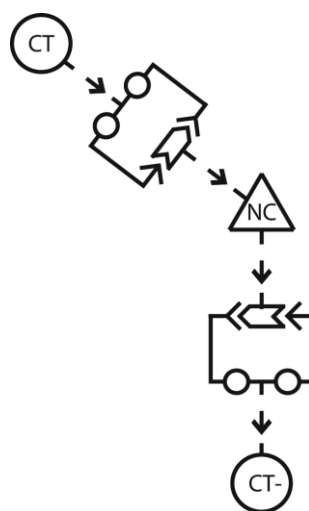


Figure 9. Cognitive type (CT) exposure to mediated nuclear content (NC) results in diminished CTs (CT-).

own right and vice versa. The actual object does not have to be present because semiosis is about using something to stand for something else.

Stage 4.1 Augmented Cognitive Types

Direct experiential knowledge coupled with experiences of NC expands the CT. Associative mapping takes place in relation to recognition. The process of semiosis is internal. NC and experiential content share some recognizable features and combine to form *augmented CTs* (CT+; Figure 10). Returning to the snakebite example, if a person is bitten by a snake for the first time, his or her diminished CT about snakebites would be augmented by the real experience of it. Likewise, if he or she had been bitten by a snake but had not previously learned what it was, via NCs of others, and if a doctor explained what snakebites were, with reference to a book on snakebites and how to treat them, the snakebite victim also would categorization starts.

Stage 4.2: Molar Content

At this level conceptual blending continues, domains of knowledge grow, and categorization develops (Figure 11). More and more knowledge of both real and mediated experience results in complex ideas represented as “molar content” (Eco, 1999, p. 141). Molar content could be described as dictionary definitions and encyclopedic knowledge that are produced and deposited in the world. In terms of creatively interacting with media, people essentially reflect on and think about the content of this type of material rather than physically manipulating it. Embodied semiotics provides a way of thinking and acting in the world at many different levels. Crucially, though, much of the cognitive process is enacted through people’s interaction with the signs that are in the environment. Indeed it was Descartes’ principal error, according to Rohrer (2007) among others, to believe that people can ever be separated from their environment.

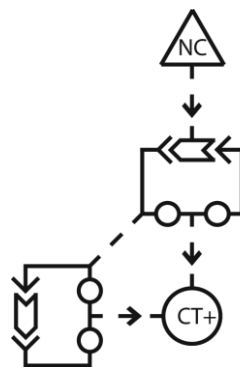


Figure 10. Exposure to mediated nuclear content (NC) leads to the development of augmented cognitive types (CT+) and to increased knowledge.

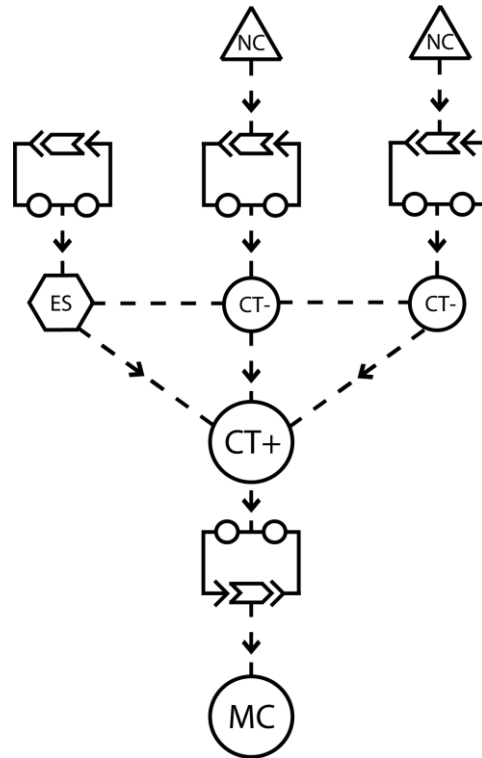


Figure 11. Cognitive types, as diminished CTs (CT-) or augmented CTs (CT+) expand into molar content (MC) as knowledge grows.

Note. ES = embodied schema, NC = nuclear content.

EMBODIED SEMIOTICS AND BLENDED SPACES

The concept of a blended space draws on the ideas of mixed reality, anchors that connect the physical and digital spaces, and the multilayered nature of interaction in this medium. We see the embodied semiotic theory as a new way of understanding these complex blended spaces. O'Neill (2008) applied the embodied semiotics theory to the analysis of some interactive devices. Here we demonstrate how it can be applied to blended spaces as well. We do not engage in a comprehensive empirical investigation at this point because the very nature of the philosophical position we have taken makes this potentially problematic. Embodied and embedded theories of mind require that knowledge be considered as situated within activities that are bound by particular social, cultural, and physical contexts. Extracting knowledge from these situations through empirical investigations runs the risk of decoupling important and subtle relationships. As an alternative, what we attempt here is to employ our theory of the levels of semiotic experience, which is grounded in the philosophy of embodied cognition, as a way to understand the multifaceted and complex nature of interaction in blended spaces. In order to see the concept of blended space and to understand the experience of blended spaces, we provide two examples where we have mapped out the relationships using our diagrams.

Example 1: NEoN Knights

NEoN Knights (Figure 12) was an event that took place at the NEoN Digital Arts Festival in Dundee, Scotland, November 2010. The designers, Jon Gill, Rick Curran, and Tim Pryde, were tasked with promoting the festival itself via the means of a game that also advertised some of the festival sponsors. Their response was to produce a Quick Response (QR) code-driven “treasure hunt” that promoted the festival via posters located across the city. In advance of the event, the posters were used to promote the festival and to encourage local people to take part. During the festival, the posters became the key component in the game, allowing participants to collect points for every QR code that was “captured” via a mobile device. The posters then played a dual role: to encourage local people to attend the festival, meaning “bringing them in,” and to encourage participants at the festival to “get out” and experience the city of Dundee. Additionally, each code was linked to a particular offer from a local business sponsor, for example, two-for-one cinema tickets, 10% off a meal, and so forth, providing people with incentives to participate and linking local businesses into the festival. The treasure hunt also had as first prize an Xbox360 game console, which was donated by Abertay University’s Hannah McClure Centre.

The blend is illustrated in Figure 13. The main objects in the physical space (the ontology) are the posters, and they are related topologically through their physical locations in different parts of the city. These provide the grounding for the anchor points into the digital space provided by the QR codes. In the digital space, there are other objects concerning the collection of points and how these relate to the offers that are blended with the physical locations of the local businesses. The temporary nature of the event means that the experience is volatile, and the sense of competition and drive adds to the dynamics of the blended space. The new agency provided by the blended space concerns the treasure hunt, the prizes, and the special offers. Thinking about how this embodied interaction unfolds semiotically, we need to begin by considering how people inhabit the spaces where it takes place. At the start of the treasure hunt, several posters with QR codes were already located across the city in largely undisclosed locations. Although a map of the locations of the QR codes was available, only the general area in which they were



Figure 12. NEoN Knights posters in the city of Dundee.

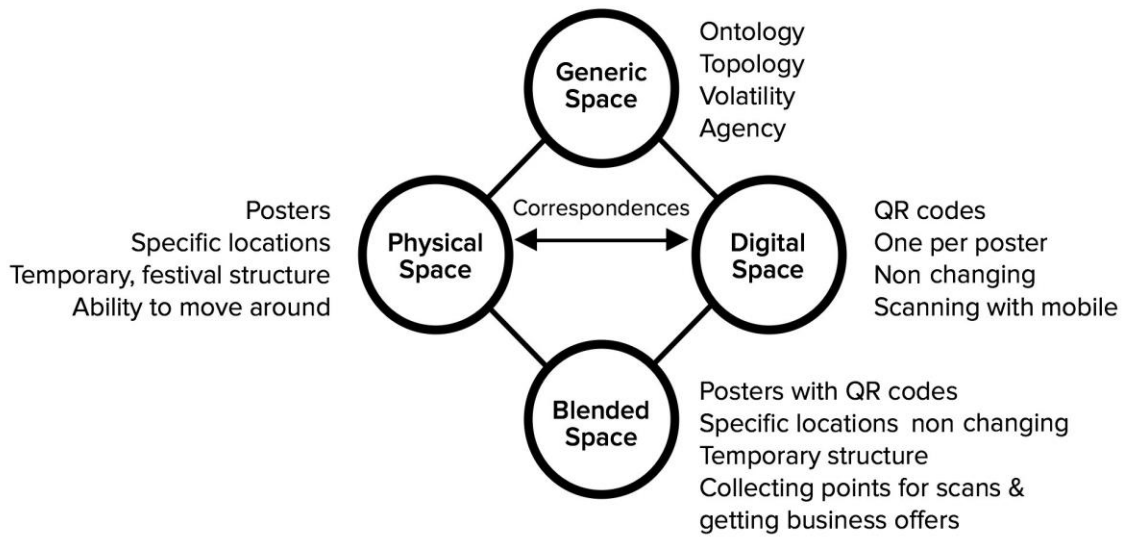


Figure 13. Blended space for NEoN Knights including Quick Response (QR) codes.

located was specified. Part of the game was to find the QR codes in the physical location. On the campaign posters, the QR codes were fairly easy to locate because the specific legal flyer-posting sites provided in Dundee were readily visible to the public (Figure 12). However, participants were essentially roaming the city in search of these QR codes to score as many points as possible. In a sense this promoted a kind of psychogeographical experience of the city akin to that of the situationist *derivé*² that could be quite disorientating (Knabb, 1981). Applying our semiotic analysis to this particular project (Figure 14), we can conceive of the space of the city as an object that is encountered bodily by the functional perception–action loops of the participants. Players had to engage bodily with the city in order to move around and collect points, therefore embodied interaction was already taking place as part of the game, and one can surmise that the embodied schemas for moving around this environment were involved in the sense making process. Likewise, players also must have marshaled whatever general knowledge (CT+) of cities they had in order to navigate through the city. CTs related to buildings, roads, paths, traffic, and people would all have been helpful for interpreting what they encountered, even though these may not be related to the specific features of Dundee. The posters themselves were multifaceted signifiers composed not only of locations but also of NCs in the form of advertising for the NEoN Festival and QR codes for playing the game. The QR codes were clearly representations of the game in that they provided the anchor points through which to engage with the digital content. The NEoN advertising that accompanied them played the role of interpretant in the sense that it provided the context for the game to be played. Interestingly though, the game itself was also a representation (and interpretant) of the festival in that it was an example of content from the festival that people could experience both as part of the festival and as a prelude to it.

Technologically, the mobile devices used to interact with the posters are another mediating mechanism for additional NCs. On one level the QR code reading software very simply translated the QR code into the URL that pointed the browser to usable content. This was relatively trivial

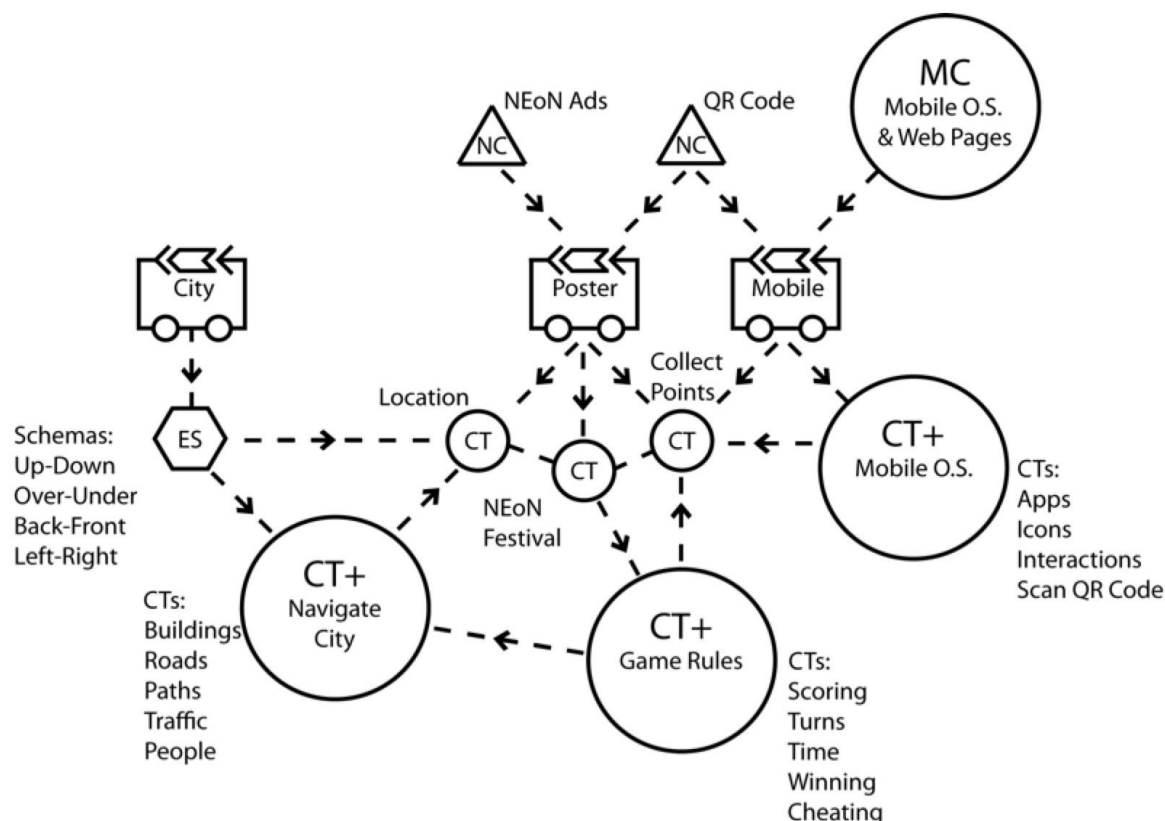


Figure 14. An embodied semiotic map of the NEoN Knights Game.

Note. ES = embodied schema, CT = cognitive type, CT+ = augmented CT, CT- = diminished CT, O. S. = operating system, QR = quick response, MC = molar content, NC = nuclear content

for the participant in that all they had to do was switch on the app and point the device at the QR code in order to read it. However, it is this physical–digital translation that really made the game possible by binding the two spaces together. Scanning the physical QR code revealed NCs related to the game in the form of Web pages that communicated the points scored. In the background, these points were tallied throughout the duration of the game, and an overall score for each participant was maintained. Molar content related to the operating system of the device is, of course, necessary to make this possible.

One interesting note is that a specific CT in terms of knowledge about the location of posters must be an emergent feature of the game because these locations were unknown to participants at the start and finding these locations was key to scoring points. Thus semiotically, finding the locations of posters was an active interpretation of the city made possible through embodied interaction within the context of the game. Likewise, knowledge of gameplay must evolve and grow. Molar content related to game playing must initially be employed in terms of understanding the rules of the game. However, the experience of playing the game must have increased knowledge of gameplay in general, perhaps specifically introducing CTs about QR-code treasure hunts. All the while, another CT was forming in the minds of the participants, a CT about the NEoN Festival. The advertisements on the posters, the Web content, and the experience of moving around the city all combined to establish new knowledge of what the NEoN festival was all about.

Each one of the interaction cycles of the functional loop could be unpacked in more detail. For example, a deeper semiotic analysis of the structure of the NC in the posters potentially would reveal additional meanings encoded by the makers of the posters. Likewise, further work could be done to investigate the actual interpretations of participants to see more clearly which aspects of their own knowledge were brought to bear on making sense during gameplay. We have held back from engaging in this level of granularity because we are more concerned here with showing how blended interactive spaces can be “mapped” semiotically using our embodied semiotic perspective.

Our analysis reveals that even simple blending of physical, technological, and cultural spaces leads to highly complex interwoven acts of signification and interpretation. The city and the festival were different spaces that were layered one on top of the other to form a blended space. This layering was made possible by the manifestation of mediating elements that physically existed in the environment of the city (the posters with QR codes) that were accessed by participants acting in the world with their mobile phones (mediating devices) to reveal digital content (points). Interaction constantly moved between the ready-to-hand operations of moving across the city and operating the QR-code-reading mobile device to capture the points and the present-at-hand activities of recognizing the posters, reading interface signs, and planning routes across the city in order to maximize point gains within the allotted time.

Example 2: Last Day in Edinburgh

Last Day in Edinburgh is a technology-enhanced walk through the streets of the part of the city known as The Old Town. The walk was developed by Serkan Ayan and based on the works of the famous writer Robert Louis Stevenson (RLS), particularly *Edinburgh, Picturesque Notes*. Using location-based technology in the form of QR codes strategically placed throughout the Old Town, snippets of RLS’s writing were delivered to the participants’ mobile phones while they were actually at the location that RLS was referring to more than 130 years ago. In a sense, the participants were following in RLS’s footsteps on a guided tour around the part of Edinburgh that was familiar to RLS. The Old Town has changed little since 1878: Much of what RLS described is still there today. Six different locations, featuring particular landmarks, across a 0.7-mile course are pinpointed carefully in relation to RLS’s writing, and a map was created to display them (Figure 15). Six QR codes, along with pictures of RLS, were placed in these environments in order to anchor the digital content to the location. An additional four anchor points were added along the route between these locations to provide more information about RLS, for example, poetry, pictures, and a video. The aim of this extra content was to establish a link between all the locations and an awareness of the experience as a totality. The walk took about 15 minutes to complete, in addition to the time the users spent experiencing the content that was provided. Thus the main objects in the physical and digital spaces corresponded one-to-one; the places and views today corresponded to those described 130 years ago. The topologies of the spaces corresponded with each other again providing a natural mapping for the blended space.

The structure of the blend is illustrated in Figure 16. The ontology of the physical and digital spaces is dictated by the specific places that RLS wrote about and, of course, the physical topology of the space dictates the relationship between the places. The user has to climb the hills and walk through the wynds (streets) in order to get to the next place on the walk. The walk is a stable, nonvolatile structure because it is based around the physical places. However, at

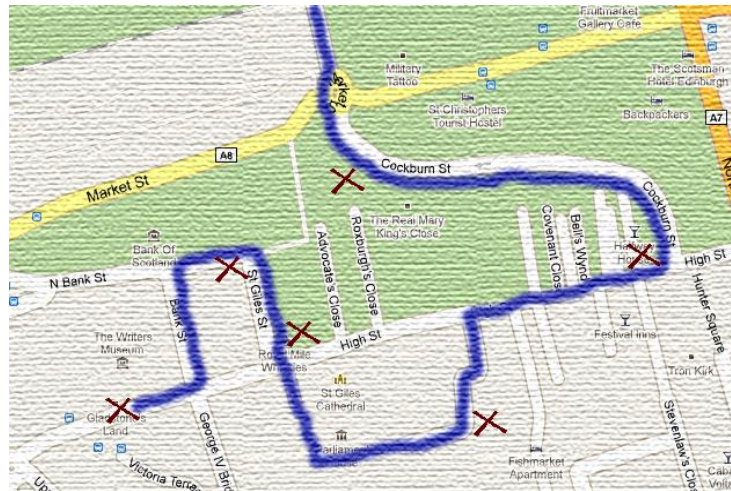


Figure 15. The Last Day in Edinburgh map.

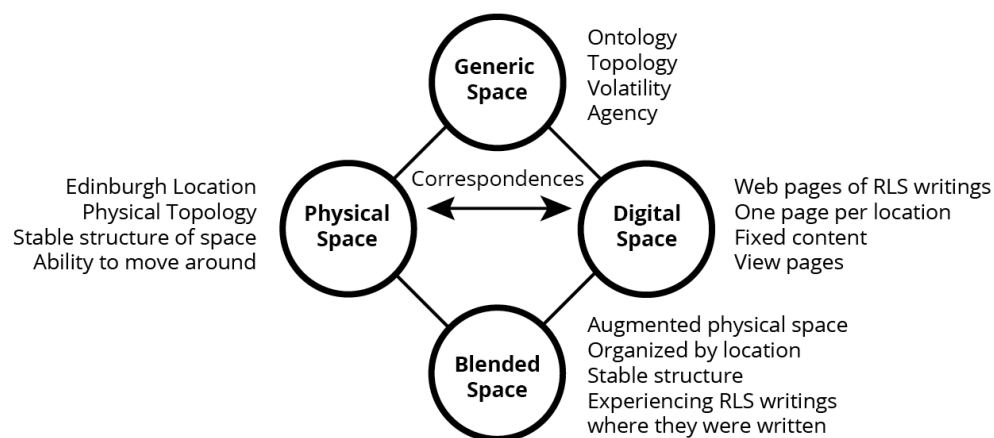


Figure 16. The structure of the Robert Louis Stevenson (RLS) space.

different times of day, there will be other people around and moving through, so the overall user experience depends on the volatility of others. In terms of agency, the blended space provides the new experience of engaging with RLS's works in their physical location.

Employing the same approach as outlined earlier, we can analyze the various components of the blended space to see how they combine together to allow for a meaningful experience to take place (Figure 17). Similar to the first example, the city (Old Town) can be considered an object to be explored by the participants by bodily moving through the environment. At the level of pure experience, there are the sights, sounds, smells, and textures of Edinburgh itself. The quality of the light, the color and texture of the stone walls, and the freshness and smell in the air are all facets of the real world that are available to the embodied participant present at the various locations visited. They were also available in a similar form to RLS when he was in Edinburgh and, at its core, it is this experience of the world that the participants are asked to compare with the mediated experience of RLS. Unlike the first example, however, the participants are armed

with a map that depicts a route that they must follow. The map has its own perceptible qualities but, most importantly, it is the NC of the tour's designer, which is present on the map, that defines the route to be taken and the locations in which to seek out QR codes.

In terms of embodied experience, the participants' perceptual capabilities are smoothly engaging with the environment in order to navigate the streets independently. Moving successfully along the road, in the right direction, negotiating bends, curves, cars, cobblestones, and curbs, all requiring the use of embodied schemas in concert with molar content about cities in general to orchestrate sophisticated movement through a complex environment. Moreover, reading the map and perceiving the embedded QR codes at various points along the route plays an important part in being able to progress through the experience. Again, an emergent CT about location (location now) is fundamental to making this possible.

Upon perceiving the posters, which include QR codes and pictures of RLS, the participants recognize the elements presented there. At a semiotic level, embodied schemas lay the foundations for a reading of the material: People understand the orientation of the material, they understand the flow of the text, they perceive coherent wholes and parts in its structure, and they begin to interpret what is seen. Pictures of RLS in relation to QR codes confirm for the participants that they are on the right track.

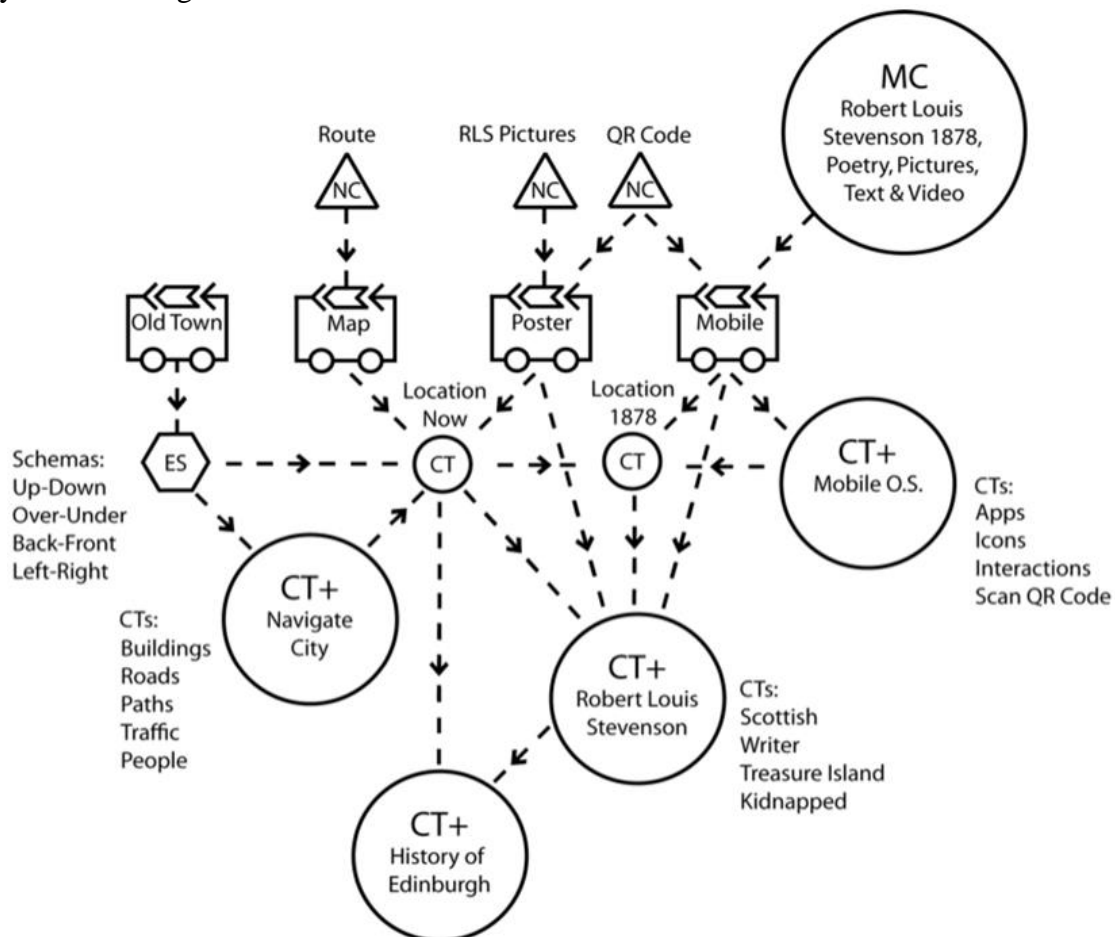


Figure 17. An embodied semiotic (ES) map of The Last Day in Edinburgh tour.

Note. CT = cognitive type, CT+ = augmented cognitive type, CT- = diminished cognitive type, O. S. = operating system, QR = quick response, MC = molar content, NC = nuclear content, RLS = Robert Louis Stevenson

On scanning the QR codes, the device itself proceeds with its programme of actions in order to render the digital content to the screen (or through the audio channel) making it available to the participant. This new congregation of signs feeds into the experience providing a new CT around RLS's words that describe the location as he saw it over 130 years ago (location in 1878). Participants interpret those words in relation to their location now: "Is what RLS says true? Does it hold today? How does that relate to my experience now? How do I feel about Edinburgh?"

Additional NCs in the form of more pictures, poetry, and video provide more background context for understanding the relationship between RLS and the Old Town. Longer trains of thought travel deeper into the semiotic realm, making more connections and adding meaning to the experience. In particular, any knowledge of RLS will be brought into relation with knowledge about Edinburgh and perceptions of the location now. Molar content is cemented into the minds of the participants in the form of their own experience of the locations, coupled to the mediated NCs. Knowledge about RLS and the history of Edinburgh are emergent as part of this process.

In some ways, Last Day in Edinburgh was a much more sophisticated kind of experience than NEoN Knights. Where NEoN Knights provided a less structured but more open engagement with the city, Last Day in Edinburgh brought in additional intellectual material, through the words of RLS, that made participants question their experience of the city in relation to its past. This additional layering of description and narrative content provides a different way to engage with the city that is not present when simply walking around on one's own. And yet it is the simplicity of walking around the city that makes this content so powerful and emotive. The key to this is the direct relationship between the real world (the objects that the participants witness) and the words of RLS (a representation of Edinburgh from the past). The fact that the technology instantaneously makes these words available while participants are at the same location as was RLS brings the past and the present together into one blended space.

CONCLUSION

People are living in a physical world increasingly augmented by virtual displays and populated by interconnected information and communication devices. This new medium needs new approaches to assist designers. The notion of embodied interaction characterized by Dourish (2001), but also identified by others such as Malcolm McCullough (2004), is a candidate for this. Bringing it together with the philosophy of Lakoff and Johnson (1999) and Rohrer (2007) provides an interesting link between the phenomenological underpinnings identified by Dourish and the psychological and neurological evidence for embodied thought. Finally, we characterize these new pervasive computing environments as blended spaces and focus on the way in which people make sense of these experiences as they navigate through them (Benyon, 2014). As these spaces become increasingly prevalent and familiar and people begin to inhabit them more regularly, they may well become blended places where people not only make sense of their activities while there but revisit them often, developing relationships and attachments to them.

People create meanings through the couplings of action with a range of mediated components in a blended space. Some of these components are simple, such as buttons or gestures; others are more complex cultural affairs, such as reading RLS's descriptions of place. Taken together and situated in a particular environment, they produce a holistic experience. Therefore, rather

than designing for the simple, functional use of devices, designers should be designing to enable the appropriation of media. For example, an extension of the Last Day in Edinburgh experience would be to facilitate the population of the blended space with visitors' comments about their own experiences, providing a huge wealth of content related to RLS that would evolve over time, just as the real place would.

We suggest that conceptual blending offers design guidance for the design of blended spaces. However, we acknowledge that there is a long way to go before this knowledge is formalized properly. Imaz and Benyon (2007) offered some high-level advice, but there is work to be done to explore the different types of blends and the use of design principles such as the optimality principles (Fauconnier & Turner, 2002). We note, though, the importance of a material anchor (Hutchins, 2005) as a contribution to blending theory. Having a material anchor for one of the input spaces grounds the blended space design in people's embodied semiotics. The material anchors of place utilized in the RLS blended space and the material anchors of the posters in NEoN Knights help the blend to make sense to people. We believe that the combination of the embodied semiotics, the multilayered ways that people make meanings, and the ideas of conceptual blending offer a powerful conceptual tool for understanding and designing blended spaces.

Blended spaces bring the real, the mediated, and the virtual together into one space, but one may feel present in any of these locations at any one time. While attending to the streets of Edinburgh (or Dundee), one is present in the city; while scanning a QR code, one is present in the mediation of this process; and when reading the revealed work, one is present with RLS in the Edinburgh of old. These different spaces are layered one on top of the other or, better, woven together by the technology. With our embodied semiotic approach to blended spaces, we seek not to understand them only as layered environments but as semiotic spaces that allow us to navigate these layers as parts of an all-encompassing experience. What we find is that the raw experience of the physical world, the mediating environment of devices, and the cultural aspects of digital content can all be interpreted through the body at different and complementary levels of cognition. When blended spaces are designed well, they are designed at a human scale where the blend between the physical environment, the mediating devices, and the digital content not only fit well together but also fit well with the way in which inhabitants make sense of them through embodied cognition.

Embodied cognition recognizes that cognition takes place in a physical and social world and draws upon philosophical foundations from pragmatism, phenomenology, and experiential psychology. This leads to designing for a directedness of experience, a coupling of actions and meanings, and an interaction experience that focuses on feeling present in a holistic experience despite the hybrid and mediated nature of its construction. Designers should consider the design of blended spaces as a critical process, creating experiences drawing on fundamental human abilities and looking to architecture and other design disciplines of physical interactions. They should understand and make explicit the aspects of mediation that make these spaces possible in relation to the notion that people already are thrown into a deeply mediated world. Blended spaces are simply the deepening of this situation and soon will become the background against which tomorrow's generation live, just as television is to people today. The blended spaces of the future will have a history and a culture of their own that will be born out of the way in which people bodily inhabit them and make sense of them.

ENDNOTES

1. For more information on blending theory, see <http://markturner.org/blending.html>
2. This refers to an unplanned journey through a landscape.

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